AMENDMENT

under PCT Article 34

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Note: Underlined parts are amended by the amendment under PCT Article 34.

DESCRIPTION

PROVIDING SYSTEM, DEVICE AND METHOD OF NUMERICAL ANALYSIS DATA, AND NUMERICAL ANALYSIS DATA UTILIZATION DEVICE

Technical Field

The present invention relates to computer simulations such as a structural analysis, a heat conduction analysis, a fluid analysis, and an electromagnetic filed analysis using a finite element method and a finite difference method, in particular, to a numerical analysis data providing system, device and method, and a numerical analysis data utilization device to provide the numerical analysis data required for a numerical analysis, in particular, it is suitable for use in an analysis relating to a processing, an assembling, a performance of metallic materials for automobiles, home electronic appliances, an architectural field, and so on.

Background Art

According to a rapid progress of a computer technology, large-scaled numerical simulations such as a structural analysis, a heat conduction analysis, a fluid analysis, and an electromagnetic filed analysis are utilized in many industrial fields, and many commercially available softwares are spreading respectively.

On the other hand, it is necessary to correctly input appropriate physical property values, boundary conditions such as loads, and constraints, accurate shapes, and so on to secure a reliability, an accuracy of the simulations as stated above. Normally, an analysis engineer executing the simulation deals with these inputs individually with reference to data files, case files, and so on. In particular, as for the physical property values, it is possible to obtain reliable data independent from analysts by referring to science chronologies, manuals, and so on for simple calculations so-called as a linear analysis such as an elastic structure analysis, a steady heat condition analysis, a potential flow analysis, an electric field analysis. However, as for many problems with high nonlinearity such as an elastoplasticity analysis, a nonlinear heat conduction analysis, a turbulent analysis, a nonlinear electromagnetic filed analysis, and coupling analyses thereof, it is difficult to obtain appropriate physical property value data, and therefore, there are many cases to use different input data by each analyst. As a result, there are problems that the reliability and the accuracy of the simulation are spoiled.

Further, in case of a steel plate for automobiles, one coil extends to several hundreds of meters, and plural material properties detailed data stretching the length thereof become enormous quantity of data.

A great deal of difficulties strings along with managing these data for user's simulation while maintaining a confidentiality manually or by a simple database administration function at present when the steel plate for automobiles are used by users for dozens of coils day by day.

As actions for the above-stated problems, there is a method to distribute a database with attaching to a simulation software, but there are problems such that it is difficult to perform a maintenance such as an addition, modification, deletion of data as needed, and using compensations such as experimental expenses to obtain data can not be retrieved.

Besides, a method to provide material data via a network is disclosed in Patent Document 1, and a method to provide information required for a structural analysis via a network is disclosed in Patent Document 2. However, in the methods disclosed in the Patent Document 1 and the Patent Document 2, a conversion and a modification of provided data are possible, and therefore, a source of data, a distinction with other data become ambiguous in accordance with a continuous usage. As a result, it may cause a deterioration of reliability of the simulation, and deterioration of confidentiality.

An object of the present invention is to provide numerical analysis data and numerical analysis results with high reliability while maintaining the confidentiality in the computer simulations of the

structural analysis, the heat conduction analysis, the fluid analysis, and the electromagnetic filed analysis using the finite element method and the finite difference method, and further to enable to retrieve a compensation from the users.

Patent Document 1: Japanese Patent Application Laid-open No. 2003-36277

Patent Document 2: Japanese Patent Application Laid-open No. 2003-167925

Summary of the Invention

The present invention is to provide a desired accurate and detailed material property value required for a simulation according to a user's request, on-demand, via a network when the user performs a computer simulation. A user side computer includes a numerical analysis means, but a management of the accurate and detailed material property data required for the numerical analysis is performed in a bulk at a server side, and the accurate and detailed material property value is provided to a simulation user in an invisible state so as to secure confidentiality.

A numerical analysis data providing system according to the present invention in which a server side computer provides numerical analysis data to a user side computer connected to a network to perform a numerical analysis about a working member and a forming member created by using a desired material,

wherein the user side computer includes: an input means inputting a material name and a property item; a storage means storing addresses of the server side computer corresponded to the material name and the property item; and a material name and property item transmitting means transmitting the material name and the property item to the server side computer having the address corresponded to the material name and the property item inputted from the input means, and wherein the server side computer includes: a material property data storage means in which the material name and the property item are stored with corresponding to any one or more kinds of material property data from a mechanical property value, a thermal physical property value, and an electromagnetic property value as for plural materials; a material name and property item receiving means receiving the material name and the property item transmitted from the material name and property item transmitting means of the user side computer; an extracting means extracting any one or more kinds of material property data from the mechanical property value, the thermal physical property value, and the electromagnetic property value corresponding to the material name and the property item stored by the material property data storage means based on the received material name and property item; and a material property data transmitting means transmitting the material property

data extracted by the extracting means to the user side computer, and wherein the user side computer further includes: a material property data receiving means receiving the material property data transmitted from the material property data transmitting means of the server side computer; and a numerical analysis means performing a numerical analysis by using the material property data so that a user does not concern substances of the material property data.

A numerical analysis data providing device according to the present invention providing numerical analysis data to a user side computer connected to a network to perform a numerical analysis about a working member and a forming member created by using a desired material, including: a material property data storage means in which a material name and a property item are stored with corresponding to any one or more kinds of material property data from a mechanical property value, a thermal physical property value, and an electromagnetic property value as for plural materials; a material name and property item receiving means receiving the material name and the property item transmitted from the user side computer; an extracting means extracting any one or more kinds of material property data from the mechanical property value, the thermal physical property value, and the electromagnetic property

value corresponding to the material name and the property item stored by the material property data storage means based on the received material name and property item; a material property data transmitting means transmitting the material property data extracted by the extracting means to the user side computer; and a means making the material property data available to a numerical analysis means possessed by the user side computer but invisible to a user when the material property data extracted by the extracting means is transmitted to the user side computer.

A numerical analysis data unitization device according to the present invention receiving a provision of numerical analysis data from a server side computer connected to a network to perform a numerical analysis about a working member and a forming member created by using a desired material, including: an input means inputting a material name and a property item; a storage means storing addresses of the server side computer corresponded to the material name and the property item; and a material name and property item transmitting means transmitting the material name and the property item to the server side computer having the address corresponded to the material name and the property item inputted from the input means, and a material property data receiving means receiving the material property data extracted from a material property data

storage means based on the material name and the property item and transmitted at the server side computer; and a numerical analysis means performing a numerical analysis by using the material property data so that a user does not concern substances of the material property data.

A numerical analysis data providing method according to the present invention in which a server side computer provides numerical analysis data to a user side computer connected to a network to perform a numerical analysis about a working member and a forming member created by using a desired material, including: transmitting a material name and a property item to the server side computer having an address corresponded to the material name and the property item inputted from an input means at the user side computer, receiving the material name and the property item transmitted from the user side computer; extracting any one or more kinds of material property data from a mechanical property value, a thermal physical property value, and an electromagnetic property value corresponding to the material name and property item stored by a material property data storage means in which the material name and the property item are stored with corresponding to any one or more kinds of material property data from the mechanical property value, the thermal physical value, and the electromagnetic property value as for plural materials based on the

received material name and property item; and transmitting the extracted material property data to the user side computer so as to be available to a numerical analysis but invisible to a user at the server side computer, and further receiving the material property data transmitted from the server side computer, at the user side computer.

Brief Description of the Drawings

Fig. 1 is a view showing a configuration of a numerical analysis data providing system according to a first embodiment;

Fig. 2 is a view showing an example of a structural analysis input data by a direct input;

Fig. 3 is a view showing an example of a structural analysis input data by an external input;

Fig. 4 is a view showing an example of a reference table making a connection with data server addresses while using a material name, a data type, a model identification number as search keys;

Fig. 5 is a view showing an example of a reference table making a connection with numeric data while using the material name, the data type, the model identification number as the search keys;

Fig. 6 is a view showing an example of an input screen of a user side computer;

Fig. 7 is a flow chart for explaining a flow of a data provision;

Fig. 8 is a view showing a configuration of

numerical analysis results providing system according to a second embodiment;

Fig. 9A is a view showing an example of an analysis model;

Fig. 9B is a view showing an example of an analysis result (distorted distribution) of the analysis model; and

Fig. 10 is a view showing an example of an input screen of a user side computer.

Detailed Description of the Preferred Embodiments

Hereinafter, preferred embodiments of the present invention are described with reference to the attached drawings.

-First Embodiment-

In Fig. 1, a configuration of a numerical analysis data providing system is shown as a first embodiment of the present invention. As shown in the drawing, in the numerical analysis data providing system of the present embodiment, a user side computer 10 (numerical analysis data utilization device) and a server side computer 11 (numerical analysis data providing device) are connected via a network 12, for example, so as to enabling a communication according to TCP/IP protocol, and the server side computer 11 (numerical analysis data providing device) provides numerical analysis data to the user side computer 10 (numerical analysis data utilization device).

Here, an example to provide material property data in a structural analysis is described when the structural analysis by a finite element method is performed for a processing member and a forming member created by using a desired material. Incidentally, only one user side computer 10 and one server side computer 11 for each are shown in Fig. 1, but both may exist in plural.

On the user side computer 10, a data input/output program 13, a numerical analysis program 14 executing the numerical analysis, a reference table 15, a communication program 16 are implemented. Besides, on the server side computer 11, an accounting program 17, a reference table 18, a communication program 19 are implemented.

In the present embodiment, both a direct input and an external input receiving a provision from the server side computer 11 are possible as an input of physical property data (material property data) for the user side computer 10.

In Fig. 2, a direct input example of the physical property data for the user side computer 10 is shown. In general, an input data 1 of a structural analysis by a finite element method is composed of a nodal point data 3 representing coordinates of respective nodal points, an element data 4 representing nodal point numbers composing respective elements, a physical property data 5 representing a physical property of the element, a geometrical shape data 6

representing a geometrical shape such as a shell thickness of the element, a boundary condition data 7 representing a load and a constraint, a calculation condition data 8 representing a time increment, a convergence condition, and so on, in addition to an analysis title data 2, and so on.

In the example shown in Fig. 2, total eight numeric values of a modulus of elasticity (Young's modulus, Poisson's ratio), a work hardening characteristics (yield stress, plastic coefficient, work hardening index, offset distortion) based on an n-th power hardening model, an anisotropy parameter (Lankford value), and a density are directly inputted as the physical property data 5 respectively. The structural analysis program (numerical analysis program 13) reading the input data performs a creation of a stiffness matrix, a solution of simultaneous linear equations, calculations of a displacement, a strain, and a stress, and an output of results.

On the contrary, in Fig. 3, an external input example of the physical property data for the user side computer 10 is shown. Here, the input data other than the physical property data 5 are the same as the ones directly inputted as described in Fig. 2. "SOURCE=NET" in the physical property data 5 is to specify that the physical property data is stored at the server side computer 11 on the network 12. A material name of "spcc", a material model

identification number of "003" (called as a property item including the data type "MECHANICAL: mechanical property") are inputted from an input means of the user side computer 10. Here, the material model identification number is to identify a type of the physical property data (mechanical property, thermal physical property, electromagnetic property, other physical properties, and so on), a type of material model (elastic, elasto-plastic, visco-plastic model, and so on), a name of an analysis program, a version, and so on, and therefore, it is not necessarily to be a single numeric value, and it may be plural code numbers and so on.

The structural analysis program (numerical analysis program 14) reading the input data shown in Fig. 3 refers to the reference table 15 in which the material name, the data type, and the material model identification number are corresponded to addresses of the server side computer 11 (data server) being a storing place of the material property data as shown in Fig. 4, based on the material name and the material model identification number, and connects to the corresponding server side computer 11 on the network 12.

At the server side computer 11, it becomes possible to provide the material property data only to a specific user by performing an authentication of a user at a time a connection is started. The server side computer 11 accepting the connection calls the

material property data from a database by using, for example, the material name and the material model identification number as search keys with reference to a reference table 18 as shown in Fig. 5, based on the requested material name and material model identification number, to transmit to the user side computer 10 in an appropriate format.

At this time, the server side computer 11 records actual usages by each user such as a connect time, a data transfer amount, after a receiving of the user side computer 10 is confirmed, to thereby perform a charging. For example, a transmission log file (client name, connection date and hour, transmission data amount, and so on) is updated each time when the material property data is transmitted to the user side computer 10, and it is totalized regularly to charge in accordance with a total communication amount.

The structural analysis program (numerical analysis program 14) executed on the user side computer 10 receiving the material property data substantially performs a creation of the stiffness matrix, a solution of simultaneous linear equations, calculations of the displacement, the strain, and the stress, and an output of results. As the structural analysis program, for example, NASTRAN, MARC, ABAQUS, LS-DYNA, PAM-CRASH, and so on are known.

Incidentally, at the user side computer 10, the numeric value of the received material property data

may be displayed to a user in a visible state, but it enables a reuse (unauthorized copy) of the once provided material property data. Consequently, it is desirable to encrypt the material property data at the server side computer 11 and then to transmit to the user side computer 10. In this case, the numerical analysis program 14 can use the encrypted material property data for the analysis by decrypting the data, but it is possible to secure a confidentiality of the data and to prevent the reuse of the numeric data by making the data invisible to the user.

Incidentally, an input style and format are not limited to the above-stated example, and they may have arbitrary style and format by each software. For example, an input screen as shown in Fig. 6 may be displayed on a display device of the user side computer 10. In this input screen, a material name 601 (for example, a standard name such as JIS, DIN, or a standard name by each manufacturer is inputted. "JSC590" in the shown example), a data type 602 ("MECHANICAL: mechanical property" in the shown example), are inputted respectively, and a material model 603 (elasto-plastic 1: static deformation) is to be selected after an object model is selected. A set button 604 is press-operated, and thereby, it is connected to the corresponding server side computer 11 on the network 12 with reference to a reference table in which the material name, the data type, the

material model are corresponded to addresses of the server side computer 11 (data server) being the storing place of the material property data.

Next, a flow of a data provision in the present embodiment is described with reference to a flow chart in Fig. 7. At the user side computer 10, after the input data of the structural analysis shown in Fig. 2 or Fig. 3 is read (step S701), according to whether direct input or external input (step S702), a numeric data is read (step S703), it is stored in a memory of the computer, and a calculation is started immediately (step S711), in a former case. Besides, in a latter case, an inquiry is performed into the reference table shown in Fig. 4 (step S704), a destination for connection of the server side computer 11 is obtained, and the connection is started (step S705).

When the connection is started, a user identification number (ID) and a password are validated (step S706), and when an authentication succeeds, required material property data are requested based on the material name, the data type, the model identification number, and so on, then a data main body, namely the material property data are received (step S707), it is stored in the memory (step S708), the connection with the server side computer 11 is terminated (step S710), and thereafter, the calculation is started immediately (step S711). Besides, when the connection with the server side

computer 11 is terminated, a charging table of the server side computer 11 is updated (step S709).

-Second Embodiment-

In Fig. 8, a configuration of a numerical analysis results providing system is shown as a second embodiment of the present invention. In Fig. 8, the same reference numerals and symbols are used to designate the same and corresponding components as the above-described first embodiment, and the detailed description thereof will not be given. Here, the numerical analysis program 14 is implemented not on the user side computer 10 but on the server side computer 11. Namely, the user side computer 10 only has functions for an input of data of the material name and the property item and for a display of analysis results.

In case of the present embodiment as shown in Fig. 3, the nodal point data 3 representing the coordinates of the respective nodal points, the element data 4 representing the nodal point number composing respective elements, the geometrical shape data 6 representing the geometrical shape such as a shell thickness of the element, the boundary condition data 7 representing the load and the constraint, the calculation condition data 8 representing the time increment and the convergence condition, and so on, other than the physical property data 5 are inputted, "SOURCE=NET" is set in the physical property data 5, and the material name

and the material model identification number (called as the "property item" including the data type) are inputted.

The structural analysis program (numerical analysis program 14) reading the input data shown in Fig. 3 refers to the reference table 15 in which the material name, the data type, and the material model identification number are corresponded to addresses of the server side computer 11 (data server) being the storing place of the material property data as shown in Fig. 4, based on the material name and the material model identification number, to connect to the corresponding server side computer 11 on the network 12.

At the server side computer 11, the connection is authorized only for a specific user by performing the authentication of the user when the connection is started. If the connection is authorized, the user side computer 10 transmits the input data of the structural analysis shown in Fig. 3. Incidentally, after the input data is transmitted, the connection with the user side computer 10 can be once released.

The server side computer 11 receiving the input data, calls the material property data from the database main body while using, for example, the material name and the material model identification number as the search keys with reference to the reference table 18 as shown in Fig. 5, based on the requested material name and the material model

identification number.

The structural analysis program (numerical analysis program 14) executed on the server side computer 11 performs the creation of the stiffness matrix, the solution of simultaneous linear equations, the calculations of the displacement, the strain, and the stress, by using the material property data called from the database main body and the input data (nodal point data 3, element data 4, geometrical shape data 6, boundary condition data 7, calculation condition data 8, and so on) received from the user side computer 10.

Subsequently, analysis results files of the displacement, the stress distribution, and so on are replied to the user side computer 10 as, for example, an attachment of an electric mail. In Fig. 9A and Fig. 9B, an analysis model and analysis results (deformed shape) thereof are shown as an example. Such results are replied to the user side computer 10 as the attachment of the electric mail.

Also in this case, the transmission log file (client name, connection date and hour, transmission data amount, and so on) is updated at the server side computer, for example, each time when the analysis results file is transmitted to the user side computer 10, and it is totalized regularly to charge in accordance with the total communication amount.

Incidentally, the input style and format are not limited to the above-stated example, and they may

have arbitrary style and format by each software. For example, the input screen as shown in Fig. 10 may be displayed on the display device of the user side computer 10. In this input screen, a material name 1001 (for example, a standard name such as JIS, DIN, or a standard name by each manufacturer is inputted. "JSC590" in the shown example), a data type 1002 ("MECHANICAL: mechanical property" in the shown example), are inputted respectively, and a material model 1003 (elasto-plastic 1: static deformation) is to be selected after an object model is selected. Besides, at another screen, required model data such as the nodal point data, the element data, the geometrical shape data, the boundary condition data, the calculation condition data are defined, and the input data of the structural analysis as shown in Fig. 3 is created by press-operating an input data write button 1004. Subsequently, a transmission button 1005 is press-operated, and thereby, it is connected to the corresponding server side computer 11 on the network 12 with reference to the reference table in which the material name, the data type, and the material model are corresponded to addresses of the server side computer 11 (data server) being the storing place of and the material property data.

Hereinabove, the embodiments of the present invention are described. However, connection modes of the computers shown in Fig. 1 and Fig. 8 are not limited to these examples, but a user's computer

(user side computer 10) may be directly connected to a data server (server side computer 11) via a telephone line.

Besides, in the above-stated embodiments, the structural analysis is exemplified, but it may be applied to a heat-transfer analysis, a fluid analysis, an electromagnetic filed analysis. As a heat conduction analysis program, for example, MARC, ABAQUS, LS-DYNA, and so on are known. Besides, as a fluid analysis program, for example, FLUENT, STAR-CD, PHOENICS, FIDAP, and so on are known. Further, as an electromagnetic filed analysis program, for example, JMAG and so on are known.

Besides, contents of the numeric data provided by the present invention is not limited to the material property data, and for example, it may be arbitrary data necessary for the numerical analysis such as a boundary condition data, a CAD data representing a shape of an analysis object.

-Example 1-

A press forming analysis system of steel sheets shown in Fig. 1 is experimentally manufactured while applying the present invention. A part of the input data is shown in Fig. 3. Here, the nodal point data and the element data are shape data of a mold or a material to be processed, and directly inputted by a normal method. The physical property data is the mechanical property of the material to be processed (data type: MECHANICAL), and the external input via

the network (SOURCE=NET) is specified as the input method. The material is a cold rolled mild steel with a board thickness of 1.2 mm (material name: spcc), and as the material model, an elasto-plastic n-th power hardening law model (material model identification number: 003) prepared by an analysis software, is specified. Subsequently, the boundary condition data are a tool movement, a blank holding load, a friction coefficient, and so on, and they are directly inputted by the normal method. In the last, the calculation conditions are the time increment, the convergence condition, and so on, and they are also directly inputted by the normal method.

Subsequently, the above-stated input data of the material name and the property item are read into a press forming analysis software existing on the server side computer 11, processed in the sequence shown in Fig. 7, an address of the data server (www.abc.com) is obtained from the reference table shown in Fig. 4, to connect to the server via the Internet. Subsequently, the material property value data which are equivalent to the directly inputted data shown in Fig. 2, namely, corresponding to total eight values of the modulus of elasticity (Young's modulus, Poisson's ratio), the work hardening characteristics (yield stress, plastic coefficient, work hardening index, offset distortion) based on the n-th power hardening law model, the anisotropy parameter (Lankford value), and the density are

received from the server side computer 11, stored on the memory, and thereafter, a forming calculation by the finite element method is performed. At this time, at the server side computer (www.abc.com), the number of times of data transmission is recorded by each user, and the charging in accordance with the data transmission amount is performed. By using this system, it is not necessary for a user (analyst) to concern substances of the material property data at all, efforts to obtain the material property data are saved drastically, a reliability of the analysis results is increased, and the analysis time is reduced. On the other hand, it is possible for a manufacturer side providing the data server to perform a unified control of the latest material property value data constantly, and to maintain the confidentiality of the data.

-Example 2-

A press forming analysis system of steel sheets shown in Fig. 8 applying the present invention is experimentally manufactured. The user side computer 10 read in the input data shown in Fig. 3, obtains the address of the data server (www.abc.com) from the reference table shown in Fig. 4 to connect to the data server via the Internet, and transmits all of the input data to the server side computer 11. Subsequently, the server side computer 11 receiving the input data obtains the material property data from the reference table shown in Fig. 5, and

executes a forming analysis. When the calculation is terminated, the calculated result is sent to a user specified in advance by an electric mail, and performs a charging in accordance with the calculation time. By using this system, it is not necessary for the user to install the numerical analysis program individually, in addition, it becomes possible for the manufacturer side providing the data server to perform the unified control of the latest material property value data and the analysis results constantly, and to maintain the confidentiality of the data.

The above-stated user side computer and the server side computer are composed of a CPU or an MPU of a computer, RAM, ROM, RAM and so on, and the present embodiment is realized by operating the programs stored in the RAM, ROM, and so on as stated above.

Consequently, the programs in themselves realize the functions of the above-stated embodiments, and constituting the present invention. As a transmission medium of the program, a communication medium (wired circuit, radio circuit, and so on such as an optical fiber) in a computer network (LAN, WAN such as the Internet, radio communication network, and so on) system to propagate and supply program information as carrier waves can be used.

Further, a means to supply the above-stated programs to the computer, for example, a storage

medium storing the program constitutes the present invention. As such storage medium, for example, a flexible disk, a hard disk, an optical disk, a magnetic optical disk, a CD-ROM, a magnetic tape, a nonvolatile memory card, a ROM, and so on can be used.

Incidentally, the shape and structure of the respective portions shown in the above-stated embodiments are to be considered in all respects as illustrative and no restrictive. Namely, the present invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof.

Industrial Applicability

According to the present invention, it becomes possible to provide numerical analysis data with high reliability while maintaining a confidentiality in a computer simulation of a structural analysis, a heat conduction analysis, a fluid analysis, and an electromagnetic filed analysis using a finite element method and a finite difference method, and a reliability and accuracy of the simulation increase significantly. Besides, it is possible to retrieve compensations for experimental expenses and so on from users, and therefore, it becomes easy to maintain and upgrade a material property data storage means (database) such as an addition, update, and so on of material property data.